 

"Climate change is upon us but we've solutions that we can use to support adaptation and early warning." Workshop Participant

IMPROVING THE USE OF CLIMATE CHANGE INFORMATION FOR ADAPTATION IN UGANDA

UNDERSTANDING THE VALUE OF CLIMATE CHANGE INFORMATION FOR WATER RESOURCE MANAGEMENT IN UGANDA – WORKSHOP - 2 MARCH 2022

REPORT PREPARED BY ASK FOR WATER GMBH (2022-6)

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It was a pleasure to work together, and we particularly thank all of the presenters for sharing their knowledge and providing their time to engage with the workshop participants.

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Abbreviations

BGS	British Geological Survey
CMIP	Coupled Model Intercomparison Project
CP	Convection Permitting
FCFA	Future Climate for Africa
GCM	Global Circulation Model
GHM	Global Hydrological Model
IGAD	Intergovernmental Authority on Development
ICPAC	IGAD Climate Prediction and Applications Centre
IMPALA	Improving Model Processes for African Climate
IPCC	Intergovernmental Panel on Climate Change
HyCRISTAL	Integrating Hydro-Climate Science into Policy Decisions for Climate-Resilient Infrastructure and Livelihoods in East Africa
MWE	Ministry of Water and Environment
NDCs	Nationally Determined Contributions
NERC	Natural Environment Research Council
RCP	Representative Concentration Pathways
UKRI	UK Research and Innovation
WASH	Water, Sanitation and Hygiene
WRI	Water Resources Institute

Cover Photo: Water Resources Related Climate Challenges in Uganda (source: Callist Tindimugaya)

PREFACE

There is little doubt that climate change is already affecting the lives of people in Uganda. Climate change is a particular challenge for the effective management of the country's water resources. Reliable information on climate change scenarios and impacts is essential to inform policy and practice. While several climate experiments (e.g. CMIP6) are already available, new experiments such as the 4.5 kilometre-scale convection-permitting regional climate simulations for Africa (CP4A) can now be used alongside the CMIP experiments and allow us to assess the impacts of intense storms in more detail than before. However, if these innovative methods are to influence policy, they first need to be well-understood and accessible. This requires capacity strengthening of the professionals and researchers so that they can analyse such experiments.

This workshop provided an opportunity for practitioners in Uganda to learn about a range of climate experiments and see results from case studies focussed on water resources, tea production and urban flooding using the CP4A and CMIP experiments. This was a great opportunity particularly for early career staff at the Ministry of Water and Environment, Ministry of Agriculture Animal and Fisheries and Uganda Electricity Generation Company Limited (UEGCL) as well as researchers at Makerere University.

Table of contents

INTRODUCTION

There is an urgent need to adapt to climate change, and ensure that long-term decisions are robust to possible future changes. This is particularly true in tropical Africa, where people are already vulnerable to extreme weather and climate variability, where there is rapid population growth and economic development, where other changes such as in land-use combine with climate change to affect the regional hydroclimate and where subsistence and other economic activities largely depend on the weather and climate conditions.

HyCRISTAL is the East African project of the Future Climate for Africa (FCFA) programme. Over the last five years, HyCRISTAL, alongside other projects, have developed new understanding of climate change in East Africa. This, coupled with growing computer power, has enabled new simulations to be undertaken. In particular the Improving Model Processes for African Climate (IMPALA) project of FCFA has run a climate change simulation for Africa at a resolution that is high enough to explicitly model the convective storms that generate tropical rainfall. These simulations have been used across all projects in the FCFA programme. Although so far, there is only one simulation, based in one possible global future, this high resolution simulation is valuable for developing methods and improving understanding on the possible impacts of climate change at a range of scales.

A one-day workshop on 2nd March 2022, hosted by the Water Resources Institute (WRI) of Uganda, set out to enable a wide range of stakeholders to understand the value and ultimately improve their use of state-of-the-art climate change information, in particular for water resources management in Uganda. The workshop format was a hybrid face-to-face/online event with 34 participants in Uganda plus 13 more online (Annex 1). Participants in Uganda comprised stakeholders from the Ministry of Water and Environment (MWE), Ministry of Agriculture Animal and Fisheries, Uganda Electricity Generation Company Limited and Makerere University, of which a large proportion were early career researchers. Online participants were researchers working on climate change and its effects (see Annex 2 for the biographies of the presenters).

The workshop was structured into two sessions, as detailed in Table 1 and summarised below:

- Morning – a high-level overview of global climate change issues and the latest research on impacts of climate change across Africa, with a particular emphasis on Uganda and East Africa.
- Afternoon – explored aspects of climate change in Uganda and the Lake Victoria Basin region, including potential impacts on water resources and the environment, WASH, agriculture, energy, transport and food security. The session showcased the latest high resolution climate simulations now available for Africa and discussed their use alongside conventional model experiments to provide information for risk-based decision-making.
- The two sessions included group and individual activities to embed learning form the workshop, facilitate discussion and capture key priorities for the use of climate information for water resources planning and policy in Uganda.

FIGURE 1 PARTICIPANTS UNDERTAKING MORNING GROUP WORK (SOURCE: GWENDOLYN KYOBURUNGI)

SESSION 1: CLIMATE CHANGE IMPACTS AND THE ROLE FOR NEW EXPERIMENTS

The first session opened with introductions, a welcome and the short film produced by the FCFA Programme, "Building climate change resilience in Africa - the story of Future Climate for Africa" [1]

FIGURE 2 SCREENSHOT OF INTRODUCTORY FILM (SOURCE: FCFA[1])

TABLE 1: PROGRAMME

9:00 – 10:00	Registration with welcome tea	WRI
	Session 1 Climate change impacts and the role for new experiments	
10:00 – 10:20	Welcome and film	Daniel Opwonya
10:20 – 10:40	The need for Climate Change Data and Information for Decision-Making in Uganda	Callist Tindimugaya (MWE)
10:40 – 11:00	Latest understanding of Climate Change in Eastern Africa; Linking Science and Policy	Geoffrey Sabiiti (ICPAC)
11:00 – 12:00	Group work 1 – Impacts of climate change and priorities for Uganda	Daniel Opwonya
12:00 – 12:30	New & existing model experiments (CP4, CMIP)	Herbert Misiani (ICPAC)
12:30 – 14:00	Lunch	WRI
	Session 2 Applications of new and conventional experiment for driving impact models	
14:00 – 14:15	Quiz 1 (https://tinyurl.com/MarchQuiz1)	Daniel Opwonya
14:15 – 15:30	Case study presentations by those that have used CP4 experimental results alongside conventional experiments. • Assessing groundwater recharge in Uganda using Inter-Sectoral Impact Model Intercomparison (ISIMIP2b) by Jesse Kisembe (Makerere University) • HyTea - Case study on future climate for tea production & decision making *by Neha Mittal (University of Leeds)* • HyTpp – Future changes in Lake levels for Lake Victoria *by John Marsham (University of Leeds)* • A modelling-chain linking climate science and decision-makers for future urban flood management in West Africa by *James Miller (UK Centre for Ecology and Hydrology)* • Application of rainfall predictions from a convection-permitting climate model to lumped catchment models in the Lake Victoria Basin *by Matt Ascott (British Geological Survey)*	Moderated by Daniel Opwonya
15:30 – 16:00	Short group work 2 – Climate data and information priorities	Daniel Opwonya
16:00 – 16:30	What next and quiz/evaluation (https://tinyurl.com/MarchQuiz2)	BGS & Daniel Opwonya
16:30 – 16:40	Closing remarks	Callist Tindimugaya (MWE)
16:40	Evening Tea	WRI

[1] https://www.youtube.com/watch?v=AGOMCf8fSCA

Presentation 1: The need for Climate Change Data and Information for Decision-Making in Uganda *by Dr Callist Tindimugaya*

Climate change is a concern for Uganda. The increased frequency and intensity of prolonged drought in some parts of the country is leading to water shortages, crop failure and a reduction in grazing potential, land degradation, as well as facilitating ecosystems deterioration and encroachment. Increased episodes of heavy rainfall and shifting seasonality of flooding are leading to crop loss, soil erosion, land degradation, diseases and infrastructure damage. A combination of all these uncertainties has resulted in low adaptive capacity at national, district and community levels. Rapid population growth, increased demands for hydroelectric power, agricultural production, domestic water supply and industry, as well as the degradation of natural resources due to urbanisation, industrialisation and poor land use practices are among the challenges for the country. Land degradation and deforestation are having major impacts already (Figure 3). Efforts to mainstream information on climate change into catchment planning, hydropower and water infrastructure planning and design in Uganda have commenced but more needs to be done, and, in particular capacity needs to be strengthened.

Figure 3 Water resources related challenges in Uganda (source: Callist Tindimugaya)

Presentation 2: Latest understanding of Climate Change in Eastern Africa; Linking Science and Policy *by Geoffrey Sabiiti*

Global average temperatures hit record highs during the last decade with 2016, 2019 and 2020 as hottest years. The Eastern Africa region is perceived to warm faster than the global average and is exposed to risks of increasing extreme climatic events including drought, tropical cyclones and intense heavy rainfall accompanied by floods and lake level rise impacting agriculture, water resources and infrastructure. The Sixth Intergovernmental Panel on Climate Change (IPCC) Report warns of fast, widespread and increasing threats of climate change impacts particularly in highly vulnerable regions such as EA. The actions in the revised Nationally Determined Contributions (NDCs) and related policies and programmes provide an opportunity for a national level response towards achieving the Paris Agreement goals. In summary, models agree on the direction of temperature projections but future total rainfall is uncertain. Extremes in rainfall are however more likely and might become frequent and intense. The high vulnerability of the region exacerbates the damage from extreme weather events, and despite certainty, taking actions offers a no-regret approach for adaptation.

Reflections by the online group in the Zoom chat:

- Great questions re. downscaling to catchment scales - we need to combine uncertainty info from global models with downscaling techniques (often from higher resolution models). Neha will talk about this more this afternoon about one approach, and we're working on developing these techniques further (*Dave Rowell*).
- I would advocate that for long-term planning it is important to capture the full range of possible futures so it makes sense to use the climate change from all CMIP models (they all have biases in their representation of current climate, but that doesn't in itself negate their value for studying change). *(John Marsham)*
- There was a clear message that for long-term planning you need to use a wide range of models, but also for smaller catchment scale modelling also need to think about representing convection more realistically and look at model performance through validation. *(Dan Lapworth).*

- One of the things that was suggested is to set up some sort of knowledge broker role in the Water and Environment working group so that key messages could reach the political level. It was suggested that this could come into the end of the water and environment week (*Kerstin Danert*).

FIGURE 4 PARTICIPANTS IN MORNING PLENARY SESSION (SOURCE: GWENDOLYN KYOBURUNGI)

GROUP WORK 1 IMPACTS OF CLIMATE CHANGE AND PRIORITIES FOR UGANDA

The participants were divided into four groups, i.e.: (i) Energy and Transport, (ii) Water Resources Management, (iii) Agriculture and (iv) Environment, with each group asked to consider impacts from a specific future climate scenario – increased rainfall and hotter (see Annex 3 for handout and further description of the scenario). Each group discussed and prepared a visual report on three questions:

1) What are the likely impacts on your sector?
2) What key actions are needed from now onwards?
3) As a group agree on the top three priorities.

FIGURE 5 PARTICIPANTS UNDERTAKING MORNING GROUP WORK (SOURCE:: GWENDOLYN KYOBURUNGI)

The group work outputs are captured in Box 1 to 4 below.

Box 1 Energy and transport group outputs

TRANSPORT IMPACTS	ENERGY IMPACTS
• Destruction of infrastructure e.g. bridges, roads • Docking of ferries • Road accidents, poor visibility, potholes, broken bridges • Increase in migration due to flooding, putting pressure on transport sector • Flooding of the drainage system of the roads (siltation) **ACTION POINTS.** • Re –design of bridges and roads network to incorporate factors of flooding • Construct different docking points for high and low levels • Need for early warning systems to communities • Enhance capacity for emergency response to roads • Climate smart infrastructure	• Destruction of power lines • Increase in hydro power generation and harness renewable energy.ie solar • Risk of dam failure • Increase in energy consumption (ACs) **ACTION POINTS** • Concrete poles under distribution lines • Increase generation capacity through dam construction • Increase dam through monitoring frequently • Build climate smart infrastructure

Box 2 Environment group outputs

LIKELY IMPACTS.	KEY ACTIONS	TOP PRIORITIES.
• Contamination of water sources especially point water sources • Decrease on land cover • Encroachment on wetlands during the dry season • Increased land degradation soil erosion scouring of river banks • Landslides increased • Displacement of people due to the floods • Loss in soil fertility • Destruction of water infrastructure • Behaviour changes resilience/adaption • Extinction of flora and fauna (biodiversity) unable to adapt	• Construction of reservoirs to control floods • Sensitization of the communities on disaster prone areas • Upscale implementation of sustainable land management practices e.g. climate smart agriculture, soil and water conservation practices • Considering climate change design of infrastructure • Use of climate resilient species of trees and crops • Demarcation of wetlands and river buffers • Promotion of livelihoods activities/options in hot spot ecosystems • Investment in climate resilient technologies for water and sanitation	• MORE CAPACITY BUILDING ON CP4, CMIP MODELS • UPSCALE IMPLEMENTATION OF SUSTAINABLE LAND MANAGEMENT PRACTICES • SENSITIZATION OF THE COMMUNITIES • PROMOTION OF LIVELIHOOD OPTIONS IN HOT SPOT ECOSYSTEMS

Figure 6 Participants back in plenary and taking the quiz (source: Gwendolyn Kyoburungi)

BOX 3 WATER RESOURCES MANAGEMENT OUTPUTS

IMPACTS OF increased extreme rainfall ● Increased siltation of water resources systems and reservoirs ● Destruction of water infrastructure systems e.g. dams, river banks ● Flash floods with pollution of water resources and water quality deterioration ● Increased availability of water storage **ACTION AREAS** ● Investment in flood control structures ● Strengthen early warning systems ● Investments in catchment protection and restoration measures ● Strengthen institutional frame works ● Capacity building	**IMPACTS OF extreme hotter temperatures** ● Reduction in water levels and quantity ● Encroachment of water-related resources like wetlands ● Increased water-related conflicts **KEY ACTION** ● Early warning and forecasts ● Investment in structures and infrastructures ● Strengthening institutional frameworks ● Capacity building ● Investment in catchment protection and restoration **PRIORITIES** ● INVESTMENT IN NON-STRUCTURE MEASURES ARE A PRIORITY ● INVEST IN WATER STRONG INFRASTRUCTURE

BOX 4 AGRICULTURE GROUP OUTPUTS

IMPACTS of extreme increase in rainfall **POSITIVE** ● Increased water for production ● Increased biomass e.g. wetlands, forests, pasture lands ● Groundwater recharge increased **NEGATIVE** ● Increased cost in vet and agricultural services ● Loss of animals and crops thus decrease in incomes ● Displacement of people and their livelihoods ● Pests and diseases increase and their mutations ● Loss of land and soil fertility (landslides and mud slides) ● Destruction of agricultural infrastructure (irrigation systems) ● Floods ● Siltation **NB: IN CASE OF EXTREME HOTTER TEMPERATURES CONSIDER THE OPPOSITE OF THE ABOVE.**	**KEY ACTIONS** ● Investment in climate resilient infrastructure (flood control, silt traps) ● Improved crop varieties (drought resilient) ● Alternative livelihoods ● Climate smart agriculture ● Government subsidies ● Water shed restoration ● Early warning systems ● Artificial recharge ● Afforestation ● Improve agricultural methods for soil conservation ● Invest in water harvesting infrastructure ● Rearing disease resistant animals ● Capacity building **PRIORITIES** ● INVESTMENT IN CLIMATE RESILIENT INFRASTRUCTURES ● IMPROVED CROP VARIETIES ● ALTERNATIVE LIVELIHOOD ● WATER SHED RESTORATION

PRESENTATION 3: NEW & EXISTING MODEL EXPERIMENTS (CP4, CMIP) *BY HERBERT MISIANI, DAVE ROWELL, JOHN MARSHAM & GEOFFREY SABIITI*

The objective of this talk was to introduce participants to the new and existing climate model experiments with a brief overview on where and how to access the datasets. Specifically, the talk focused on the traditional approach to climate modelling, highlighting some of the advantages and shortcomings of such approaches, providing an overview of the new simulations which are run at high spatial resolution which allow convection to develop explicitly, and providing examples of some of the benefits of using high resolution simulations. The talk concluded by providing the pros and cons of using traditional methods versus the high-resolution simulations:

- CP4A models have improvements in certain aspects

- Challenges in the analysis of data produced, computational resources, few ensemble members, limited scenarios limits quantification
- Limitations in CP4A model simulations means that they cannot replace CMIP simulations. They should be viewed as are part of solving the climate change puzzle
- Improvement in rainfall characteristics and high spatial and temporal resolutions are good for impact modelling and climate extreme analysis.

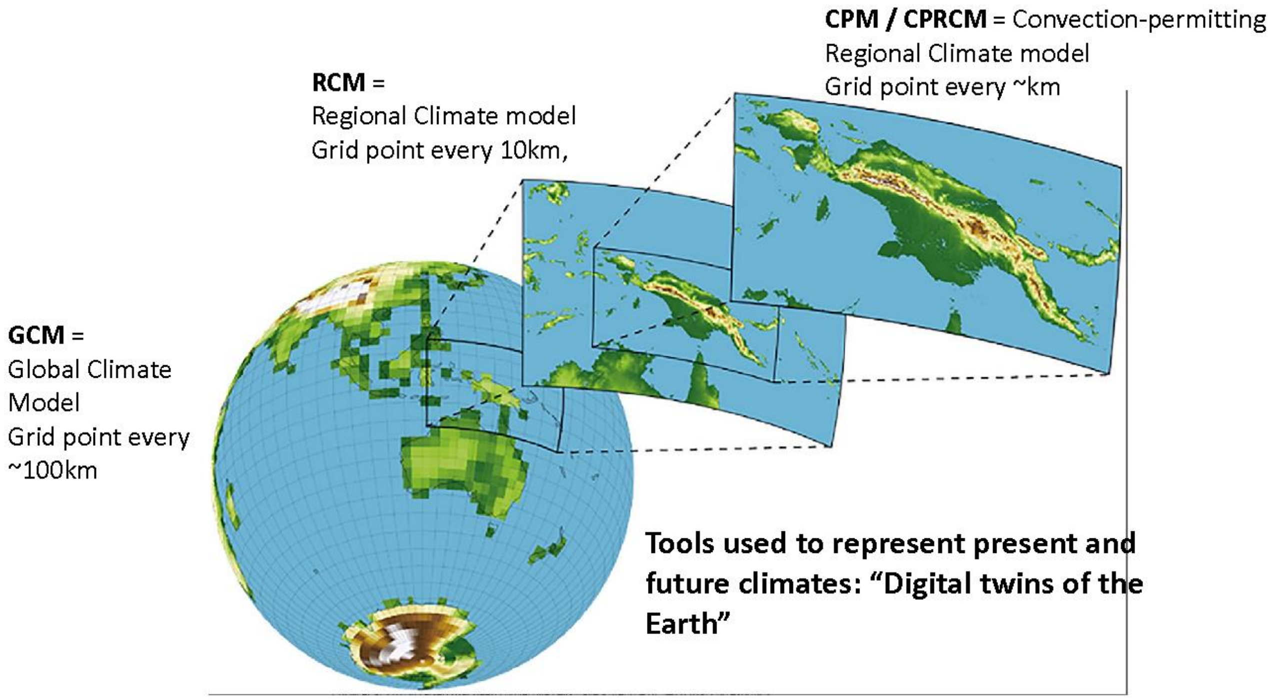


Figure 7 Extract from Presentation on New & Existing Model Experiments (CP4, CMP) (source: Lucas-Picher et al 2021[2])

Discussion

Up to what level can you scale? - The scale depends on the scale of the statistical measure that you are using. You need additional skills to be able to analyse the data, which is a topic for another day.

How do we apply these tools, and how do we make decisions and decide what to use to make decisions? You need to understand.

Can these tools be learnt, or is there capacity building required? Some capacity building is required, but there are online resources available to assist with learning.

Reflections by the online group in the chat:

- 10 years is too short for a robust statistical measure of all changes in inter-annual variability on a regional scale, but it is long enough for robust knowledge of a greater increase in extremes when you resolve processes better. It's challenging to look at rare events though as you say e.g. a future climate 1 in 100 year event *(John Marsham)*
- For using CP4A … As with any interdisciplinary work, I'd encourage anyone using it who is not very familiar with the climate science, to be talking with someone like Herbert to get the best out of the data *(John Marsham)*
- CP4A does well over the Horn of Africa region (the propagation of rainfall features is well captured, winds, Turkana Jet etc). I think the biases are more associated with rainfall from shallow clouds which are not fully resolved in the CP4A model. *(Herbert Misiani)*

[2]Lucas-Picher, P., Argüeso, D., Brisson, E., Tramblay, Y., Berg, P., Lemonsu, A., et al. (2021). Convection-permitting modeling with regional climate models: Latest developments and next steps. WIREs Climate Change, 12(6), e731.

Session 2: Applications of new and conventional experiments for Driving impact models

Presentation 4: Assessing groundwater recharge in Uganda using Inter-Sectoral Impact Model Intercomparison (ISIMIP2b) *by Jesse Kisembe*

The majority of Uganda's population relies on groundwater as an accessible source to meet their water demands especially in times of prolonged dry seasons. Its importance will likely increase with a changing climate where extreme events like drought are projected to increase in the future. However, it is still unclear how climate change will impact groundwater systems and thus the availability of this vital resource. This study investigates groundwater recharge projections using a multi-model ensemble of eight global hydrological models (GHMs) that are driven by the bias-adjusted output of four global circulation models (GCMs). Historical groundwater recharge values are compared with future recharge values as a result of two representative concentration pathways (RCPs). Results suggest that projected changes strongly vary among the different GHM/GCM combinations. Overall, groundwater recharge is projected to increase by 5-75% in most parts of the country with isolated decreases of 5-25% in the districts of Koboko, Yumbe, Arua, Nebbi, Moyo, & Adjumani in the Northwest, and Isingiro, Rakai, Mbarara, Kiruhura, Lwengo, Bushenyi in Southwestern Uganda.

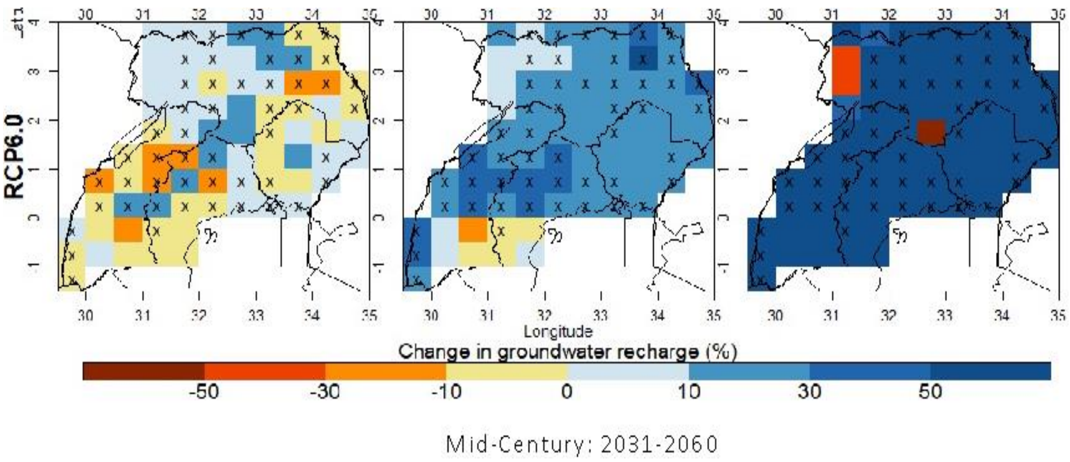


Figure 8 Extract from Presentation on assessing groundwater recharge in Uganda (source: J Kisembe 2022)

Presentation 5: CI4Tea – Case study on future climate for tea production & decision making *by Neha Mittal*

Tailored climate change information is essential to understand future climate risks and identify relevant adaptation strategies. However, distilling and effectively communicating decision-relevant information from climate science remains challenging. Through this study, we produced usable future climate information for tea growers in Kenya and Malawi. Iterative engagement with diverse stakeholders helped build trust to identify their climate information needs for long-term adaptation and decision making. Long-term stations observations provided by stakeholders alongside projections from 29 global climate models and the high-resolution climate simulations for Africa helped develop a site-specific projected range of future climates within the tea growing regions. Tea is also a very important cash crop for Uganda, and some of the plantations are close to the lake.

Figure 9 Extract from Presentation on future climate for tea production (source: N Mittal et al 2022)

Presentation 6: HyTpp – Future changes in lake levels for Lake Victoria *by John Marsham*

Changes in Lake Victoria's water level and outflow due to climate change may have far-reaching consequences for local and remote populations. The lake basin is a rapidly growing population centre, playing a pivotal role in connecting land-locked countries, and a key part of supply chains to Indian Ocean ports. The lake is one of the two major sources of the Nile, and its outflow is a major hydropower resource. The lake exhibits large natural interannual variability in water levels, with low levels in the early 2000s and extremely high levels in 2020. Ongoing development of infrastructure on and around the lake requires knowledge of potential future ranges of lake levels, and outflows, under climate change. To address the deep uncertainty associated with future changes in tropical rainfall, we analyse plausible future ranges of lake level and outflow derived from a hydrological model driven by changes from 34 CMIP5 General Circulation Models under the RCP 8.5 scenario, with outflow controlled by the existing release policy (known as the "Agreed Curve"). An increase or decrease in mean level is to be expected, with large changes in the frequency of extreme levels, even when there is a relatively small change in the mean. A sensitivity analysis shows that a small but significant additional drying combination beyond the CMIP5 range could constrain outflows. The analysis raises several questions relating to future management of the lake for water-sector stakeholders, including hydropower generators and downstream communities.

Uganda and Burkina Faso have a lot of similarities, especially if you look at Uganda's growing population and it's built environment

Presentation 7: A modelling-chain linking climate science and decision-makers for future urban flood management in West Africa *by James Miller*

This presentation presented a climate-hydrology modelling chain that was co-developed with decision-makers in the city of Ouagadougou, Burkina Faso, to assess future impacts of climate change and urbanisation on urban flooding. The presentation conclusions are:

- Importance of using high-resolution climate change data capable of representing storm generating characteristics for the West-African region when considering the interaction between mesoscale convective storms and land-cover for flooding at the city scale
- Modelling-chain serves as effective example of co-producing climate information with decision-makers for application to flood-risk in a developing country
- Approach can be used to bridge the usability gap between what scientists think is useful and what decision-makers need
- Enabled focused recommendations - based on emerging science improved local understanding of city flood risk and climate science

Figure 10 Extract from Presentation on future urban flood management in west Africa (source: J Miller 2022)

Presentation 8: Application of rainfall predictions from a convection-permitting climate model to lumped catchment models in the Lake Victoria Basin *by Matthew Ascott*

Convection permitting (CP) climate models have been developed to address deficiencies in conventional climate models which use parameterised convection. Here we apply the outputs of a CP climate model as inputs to lumped rainfall-runoff models in the Lake Victoria Basin. We show that whilst the CP model produces greater stream flows than a model using parameterised convection, changes in extreme stream flows relative to changes in mean stream flows are limited. This is a result of the rainfall-runoff model structure and parameterisation which buffers rainfall extremes. This structure is associated with catchment storage dynamics, which may be ubiquitous in humid regions.

Questions and Discussion

To Matthew Ascott - Does the simulation compare well with the local data? How does the local data compare with the CP4? We undertook sensitivity analysis on the climate model and impact on stream flows, but have not done bias correction or compared against the local data. Overall, all global climate models have rainfall that is too light & too widespread. CP4A has rainfall that is too heavy on the 4km scale, but much better on the 25-km scale. It organises & propagates storms better.

To John Marsham - Can the CP4 be used to assess changes in storage in Lake Victoria? The models give biases, are you able to expand on that and can you give recommendations? CP4 tends to overpredict rainfall on the 4km scale, but this can be averaged out at the 25km scale. We used a water balance approach, and so the changes in extremes on a daily time scale do not matter, but the larger scales and timescale of over a week matter. CP4 has biases with respect to the observations. It is worth noting that in many of these regions we are quite reliant on satellite data for observation so it is quite hard to evaluate these models. For the Lake Victoria work we did use CP4 data alongside CMIP but we used a water balance method. It is not the short, small changes that matter, but those at the 300 km scale and over a week. This gives a good estimation. What we would really need are a whole set of models with different time periods and driven by different global models. That is plausible within years, but is not currently available.

To Neha Mittal - The presenter (on tea) indicated that the stakeholders could not believe what they were seeing. Is this because the model is looking at a higher scale, in a topographically divergent area? Indeed, the people in the highlands of Kenya have not experienced such high temperatures as yet, although they have been experiencing droughts. They did not expect the high number of days above the threshold for stress by the tea crop. There have been incidents of droughts which have been increasing, but there have not been adaptations in terms of irrigation. It was an eye opener for them that this was going to be the case in the coming years and decades. In response to the second part of the question, our predictions are location specific projections.

To John Marsham - For Lake Victoria, extreme lake levels were correlated with extreme rainfall. Why would that be the conclusion. There can be geotechnical factors, or huge runoff with extreme sediment load that is altering the lake beds. Could these also be confounding factors, and how were these accounted for in the model? We have good evidence that climate change will increase the type of events that we saw. The intensification of rainfall does increase soil erosion which may be important for Lake Victoria but I do not know. However, I think that geotechnics may be more relevant in the smaller rift valley lakes than Lake Victoria but this is not my area. Note that the rainfall experienced was truly exceptional.

To Neha Mittal - There is a lot of subsistence farming in Uganda and can the methodology used for tea in Malawi and Kenya be transferred and used for coffee and sugar cane in Uganda so that we can prepare accordingly? Yes. It is transferrable. It is a matter of engaging the farmers in understanding the climate information needs. Access to station observations in the region is also important.

To James Miller – Our problem in Uganda is unplanned urbanisation with people building left right and centre, and how do we incorporate this lack of physical plans. Drainage is actually a nightmare within our cities. In the model, we set the parameters for the model, so that in the future, water was able to move more efficiently through the lumped catchments that we were modelling. We would expect more urban drainage as the city develops, and less ponding.

To Dan/David – the use of lumped parameter models in the Lake Victoria Basin may be affecting the outputs by simplifying processes? It would require a different type of modelling – a more distributed model that would represent the variability within the catchment if you were to look at the impacts of land use change (e.g. rural to urban, or different types). You would need a distributed model that would route the model through the catchment for different types of land use *(Dan)*. The models fit the observations pretty well for the present, but with changes, there are assumptions that the situation does not change in the future. It is a start, but we recognise that there are limitations. The model that Matthew used was simpler and focused on exploring differences between CP4A and R25 experiments rather than land use change *per-se (David)*.

General comment from Uganda participant – there has been work done on Lake Victoria Basin. It would be interesting to do the same on Lake Albert and Lake Kyoga?

Group Work 2 Priorities

Small groups of two or three persons were formed to enable the participants to reflect on their own experiences as well as what they have learned today, and identify the top three priorities with respect to climate data and climate information. The main themes that emerged were capacity building, data access, moving from science into practice. There was considerable interest in the data and models used, as well as in equipment to gather the data. Individual priorities were also captured in the online evaluation (see below).

Evaluation

A total of 32 participants took the second quiz and filled in the course evaluation. 94.6% responded that the workshop had been very useful for them, and 6.3% stated that it was somewhat useful. Going forward, the top priorities for climate data and information identified by the participants in the evaluation are summarised in Box 5. The 'most important thing that participants have learned from the workshop' were wide ranging, most likely reflecting a broad range of prior knowledge and understanding of the topics presented and are summarised in Box 6.

Box 5 Top priorities for climate data and information in Uganda

Data

- Data collection, intensified data collection network, equipment to collect data
- Data access
- Downscaling climate data to the household
- Data modelling and usability

Use of information

- Dissemination of information and scientific research, including sharing with communities
- Improved use of weather (hours to seasonal) information to improve management decisions
- Links between climate change studies and policy/implementation
- Interpreting the information or knowledge got from these climate change models to the political world
- Transfer of climate data and information from technical personnel to policy makers
- Weather forecasting in order to carry out agriculture and plan infrastructure development

Capacity building

- In climate data collection
- In use of data
- In relation to modelling, flood mapping, data access, the CP4/CMIP data
- Of relevant institutions
- Hands-on training on the models and down-scaling of data sets

Box 6 Most important thing that participants have learned from the workshop

- **Climate change impact on water resources and future projections of climate change**
- **Priorities of Ugandan stakeholders, local priorities and needs**
- **The importance of climatic data, and how climate data and information can be used to generate scenarios and inform decision making**
- **Skill and capacity building requirements of climate modelling**
- **The new simulation based in CP4; new and existing experiments and relevance of more research**
- **The need for climate information for planning water resources; the need to integrate climate change adaptation into administration and planning including water resources planning**
- **Linking scientific knowledge with decision makers; strengthening the science-policy interface**
- **"Climate change is upon us but we've solutions that we can use to support adaptation and early warning"**

The complete responses are set out in Annex 4.

What next?

In order to enable participants with an interest in accessing and using the data in the future, contacts for Herbert Misiani, as well additional information was provided. Annex 5 provides an analysis of the quiz responses, indicating potential knowledge gaps that could be addressed by WRI training in the future.

Box 7 Getting hold of CP4Africa data sets & finding out more and follow-up

Useful links for technical guidelines for using CP4A data

https://futureclimateafrica.org/wp-content/uploads/2020/12/FCFA-CP4A-full-guide-final.pdf

Step-by-step guide to accessing CP4A data

Many open access journal articles with links in the technical guidelines

Technical guideline document and some selected journal articles are provided in the workshop material for participants

Related project with data soon to be released

ELVIC project - Climate Extremes in the Lake Victoria Basin

https://ees.kuleuven.be/elvic/

Closing

Dr Callist Tindimugaya closed the workshop by thanking the organisers, presenters and funders. He noted that we had planned to have them attend the workshop physically, but this was not possible. Dan Lapworth and John Marsham also thanked WRI and the MWE for all of their preparatory work, and for hosting the event.

ANNEX 1 WORKSHOP PARTICIPANTS, ORGANISERS AND FACILITATORS

PARTICIPANTS PHYSICALLY AT THE WORKSHOP IN UGANDA

Number of participants[2]	Organisation
1	Independent Consultant
30	Ministry of Water and Environment
1	Ministry of Agriculture Animal and Fisheries
1	Uganda Electricity Generation Company Limited (UEGCL)
1	Makerere University

ONLINE PARTICIPANTS

Number of participants[2]	Organisation
3	British Geological Survey
1	UK Meteorological Office
1	University of Leeds
2	IGAD Climate Prediction and Applications Centre (ICPAC)
1	Makerere University
1	University of Leeds
1	UK Centre for Ecology & Hydrology
1	Victoria Institute of Research on Environment and Development (Kenya)
1	Ask for Water GmbH

ORGANISERS AND FACILITATORS

	Name (Role)	Organisation
	Kerstin Danert (Organiser and Facilitator)	Ask for Water GmbH
	Dan Lapworth (Organiser)	British Geological Survey
	David Macdonald (Organiser)	British Geological Survey
	Gwendolyn Kyoburungi (Organiser)	Ministry of Water and Environment
	Daniel Opwonya (Organiser and Facilitator)	Independent Consultant

[2] Names have been removed in compliance with General Data Protection Regulations

Annex 2 Presenter Bios

Callist Tindimugaya is Commissioner for Water Resources Planning and Regulation, Ministry of Water and Environment, Uganda. He has represented Uganda for many years on international and regional committees such as the Technical Advisory Committees of the Nile Basin Initiative (NBI) and Inter Government Authority on Development (IGAD), and UNESCO's International Hydrological Program. He oversaw the steering of HyCRISTAL research in Uganda.

Geoffrey Sabiiti is a researcher and academic working in the areas of climate change knowledge, impacts, adaptation and resilience in Eastern Africa. He is a Co-investigator of the HyCRISTAL project and aims to increase understanding of climate science for better and informed climate risk management, resilient systems, sustainable infrastructure and development in Eastern Africa.

Herbert Misiani is an early career climate scientist based at the IGAD Climate Prediction and Applications Centre (ICPAC) in Nairobi. He is a meteorologist by training and has interests in climate change science with a focus on climate extremes and future projections of climate over the Eastern Africa region. He has worked on research projects, including HyCRISTAL, in which he used the high-resolution climate simulations run at convection scales to understand changes in climate extremes in the Horn of Africa region.

Jesse Kisembe is a research assistant at the Department of Geography, Geo-Informatics and Climatic Sciences, Makerere University. He holds a master of science degree in Disaster Risk Management and bachelor of science degree in Meteorology, both from Makerere University.

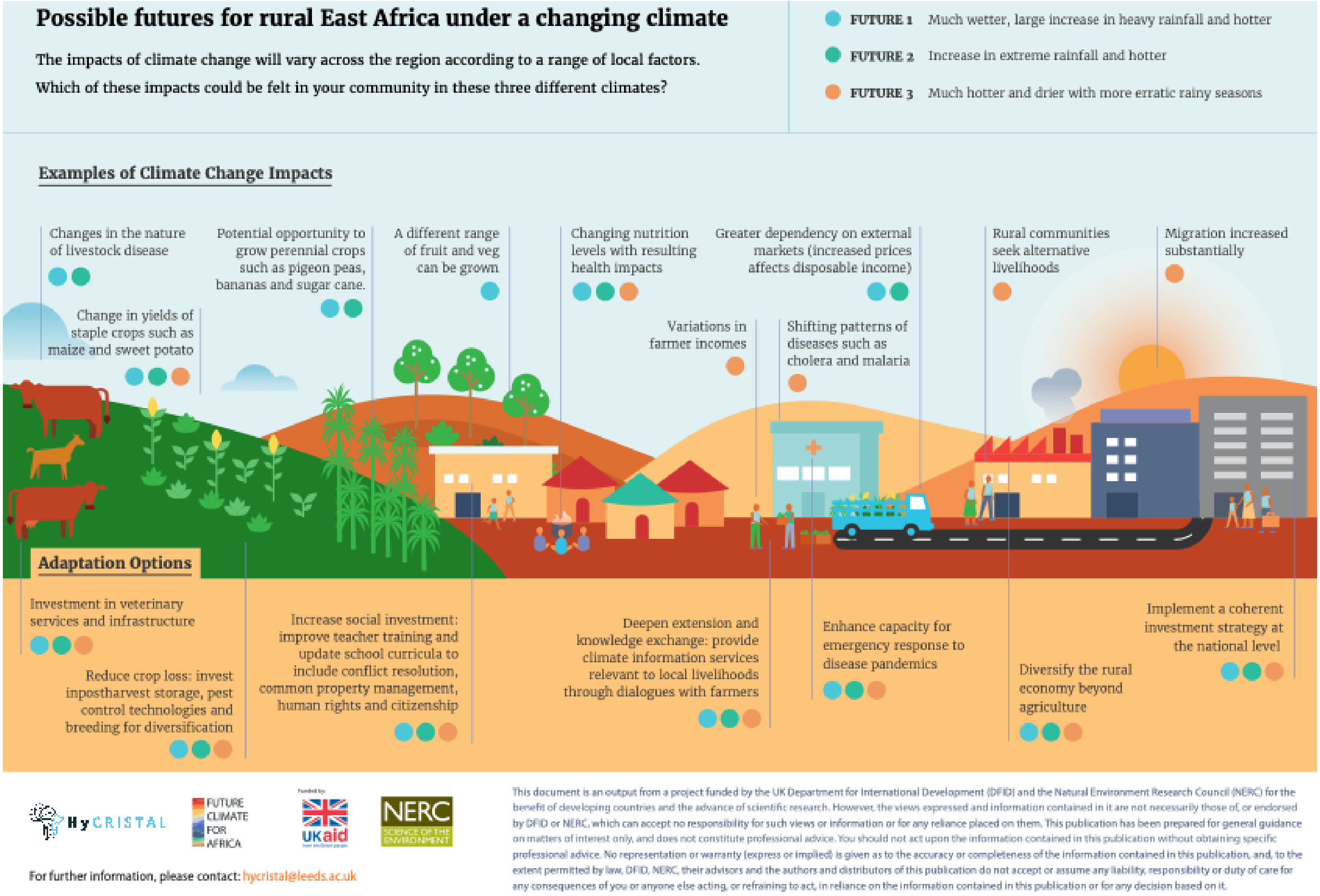
Neha Mittal's research interests are in climate services development in southern and eastern Africa. She is an interdisciplinary environmental researcher in the School of Earth and Environment at the University of Leeds.

John Marsham is Met Office Joint Chair at the University of Leeds and works on tropical weather and climate prediction, and its application in decision making. He leads the East African component of the Future Climate for Africa (FCFA) programme and is a Co-I of GCRF African SWIFT.

James Miller is an Urban Hydrologist working at UK Centre for Ecology & Hydrology for 12 years on flood estimation methods and the impacts of climate change and urbanisation on urban flooding. He was workpackage lead on the AMMA2050 project case study monitoring and modelling of flooding in the capital of Burkina Faso, Ouagadougou.

Matthew Ascott is a Senior Hydrogeologist at the British Geological Survey. Over the past 4 years Matthew has been working on the HyCRISTAL project.

ANNEX 3 CLIMATE SCENARIO HANDOUT



Source: HyCHRISTAL[3]

[3] This document is an output from a project funded by the UK Department for International Development (DFID) and the Natural Environment Research Council (NERC) for the by DFID or NERC, which can accept no responsibility for such views or information or for any reliance placed on them. This publication has been prepared for general guidance professional advice. No representation or warranty (express or implied) is given as to the accuracy or completeness of the information contained in this publication, and, to the extent permitted by law, DFID, NERC, their advisors and the authors and distributors of this publication do not accept or assume any liability, responsibility or duty of care for any consequences of you or anyone else acting, or refraining to act, in reliance on the information contained in this publication or for any decision based on it.

Annex 4 What is the most important thing that you have learned from this workshop?

Responses
Climate modelling requires expert skills
The new climate simulation based on CP4. Also, CMIP6 which is new and that it uses SSP. As well the fact that climate change simulations are still uncertain
New and existing model experiments
Priorities of Ugandan stakeholders
There is need to integrate climate change adaptation and integration into administration and planning
Importance of linking scientific knowledge with the decision makers
The importance of linking scientific research findings to policy formulation and decision making.
Need to build capacity in climate impact modelling
Climate change is upon us but we've solutions that we can use to support adaptation and early warning
Local priorities and needs
CP4 data for climate change research
Climate information is necessary for planning water resources
Enthusiasm for engagement
Use of climate data in adaptation actions at s smaller scale
Relevance of doing more research in cc.
Impacts of climate change both positively and negatively and how it be adapted.
How climate data and information can be to generate future climate scenarios and inform decision making
Modern modelling concepts related to climate change
Impacts of climate change on various sectors
Use of climate change models to predict the future weather events
Brief on CP4 and its application in the different case studies
Climate models are vital
East African temperature is above the global average of temperature
The fact that if measures are not taken we are to get to extreme levels of climate change
Climate change models
Strengthening Science-policy-interface is KEY to ensuring climate smart decision making
data acquisition and management is critical to dealing with climate change
Future projections of climate change
understanding of the climate forecast and the present of data
importance of climatic data
Climate change impact on water resources

Annex 5 Potential Knowledge Gaps by Participants

The quiz questions provided insights into the potential knowledge and knowledge gaps of participants. This information may be useful for WRI in planning future training events.

The most frequently missed question was "Please identify key challenges resulting from critical climate data/knowledge gaps for Uganda", where many participants did not identify all three correct answers, i.e.:

- Setbacks in strategic assessment and water resources planning,
- Incomplete understanding and knowledge of bio-physical conditions
- Delays in planning and execution of investment projects and water management decisions.

Respondents were also challenged with identifying all of the correct elements of the HyCHRISTAL project.

Only 44% of the respondents correctly identified Uganda as the county within the Lake Victoria Basin that has had the highest increase in mean annual temperature due to climate change. However, 80% of respondents were aware that the Lake Victoria basin will receive the most annual rainfall within Uganda as projected by future climate change model, and 72% correctly identified water supply and sanitation as the sector or activity that consumes most of the water resources in Uganda.